

# Design Tracking System for At-home Medical Equipment during Natural Disasters

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**ABSTRACT:** Electricity-operated durable medical equipment (DME), such as ventilators, dialysis machines, and patient monitoring devices, are life-supporting machines used extensively by patients at home. While convenient and economical, at-home use of DME is susceptible to power outages, especially the ones caused by natural disasters that often occur in large area and for a long duration. This system consists of two parts: a hospital-based receiving device, called the Base Station node, and multiple transmitting devices, called User Nodes, each connected to the DME at patients' homes. The Base Station and User Nodes are each built with a Arduino microcontroller, a GPS receiver module, and an Xbee® radio implementing the Zigbee® protocol. The Base Station device is programmed to receive and convey the information transmitted from the User Nodes to a nearby hospital's patient monitoring computer.

**Index Terms:** Durable Medical Equipment, GPS, Radio, Tracker, Tracking System, Wireless, Zigbee, Xbee

## I. INTRODUCTION

Durable medical equipment (DME) is any medical device used at home by patients for monitoring and/or treating diseases [1]. There are two types of DME: passive equipment and active equipment, the latter reliant on electricity to operate. Life-supporting active DME include dialysis machines, ventilators, oxygen concentrators, etc. [2]. At-home use of DME is not only convenient and economical, but also leads to a better quality of life for the patient. In a 2013 survey, the World Health Organization (WHO) estimated that in Japan alone, there are 13,000 DME in use, namely 101 DME users per million population [3]. DME are heavily used in the United States although a specific number is not available due to privacy laws [3].

Despite aforementioned benefits, at-home DME are susceptible to power outages, especially those caused by natural disasters. During difficult times like this, the DME-dependent patients had to face

the life-threatening situation because their machines had stopped functioning. While most at-home DME are equipped with integrated batteries to keep them functioning during power outages, their rechargeable batteries typically last only 1 hour with lead-acid batteries and 2-3 hours with newer lithium-ion batteries [4]. Thus, there is a critical need for a means of communication between the medical staff at a hospital and patients at home during natural disasters without needing current infrastructure such as landlines or cell towers that are often unavailable during natural disasters.

Minimal configuration and quick deployment make ad hoc networks suitable for emergency situations like natural or human-induced disasters, military conflicts, emergency medical situations etc. This is a promising technology which can improve the healthcare industry and it is finding its way into various aspects of our life. Sensor devices can be used to capture continuous data from patients in real time and communicate to doctors & Emergency Medical Technician staff (Nurses & Technicians) on their hand-held devices. This technology can prove vital in mass casualties and natural disaster where patients' records like identification, previous medication history and other vital information can be stored. This technology is expected to reduce the amount of time the doctors require to identify the problem and consult fellow doctors through use of hand-held devices communicating in ad hoc mode. Also this will reduce the amount of paper work required and the duplication of patient records.

Ad hoc network facilitates creation of a network of medical devices on the fly (Sensor network) thereby supplementing the resources at hand by providing features like reconfiguration and reallocation similar to HAM radios in use today. The devices use minimal power and are robust which decrease their dependence on available

infrastructure (resources like electricity supply, communication infrastructure like telephone lines etc which are target of insurgents or are destroyed by natural disaster) and this makes them an attractive alternative. However this technology has a limitation as the ranges of these devices are fixed and to enable these services to be extended to large geographical areas like ambulances and patient premises requires this infrastructure to interoperate with other wireless networks like GSM /CDMA mobile networks. Thus, we are looking at a new technology which is born as a result of fusion of medical sensors and mobile technology.

## II. PROPOSED FRAMEWORK

The system majorly consists of three major units: i) Medical equipment unit, ii) Main Controller unit, iii) Observer unit and these units consist of three major components: i) ZIGBEE module, ii) GPS modem, iii) Microcontroller (Atmega 328). Let us see the brief explanation of circuitry.

**Main Controller Unit :** Fig.2 shows the main controller unit consists of Zigbee receiver module, and GPS modem. The information of the Medical equipment unit received by the microcontroller by Zigbee receiver module and the same time it also receives the location through GPS modem by making the switch on and off condition of the Really which is connected in between the GPS modem and Zigbee receiver. Here the LCD of the controller unit shows the sensor output information. By the use of the Zigbee modem all the information of the Medical equipment parameters like type of equipment, Age of patient, type of disease will transmit to the Observer PC.

**Observer/Doctor Unit:** This unit is Observer's/Doctors PC. In the PC hyper terminal display all the information like all vital signs and the location of the patient.

### A. Arduino ATmega328

The Arduino Uno is a microcontroller board based on the ATmega328. It has a 16 MHz ceramic resonator, 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a USB connection, a power jack, an ICSP header, and a reset button. This board is very simple and can be easily used, everything you need to support

the microcontroller is in this board, just plug it in a computer via USB cable and power using an AC-to-DC adapter or battery to get started.

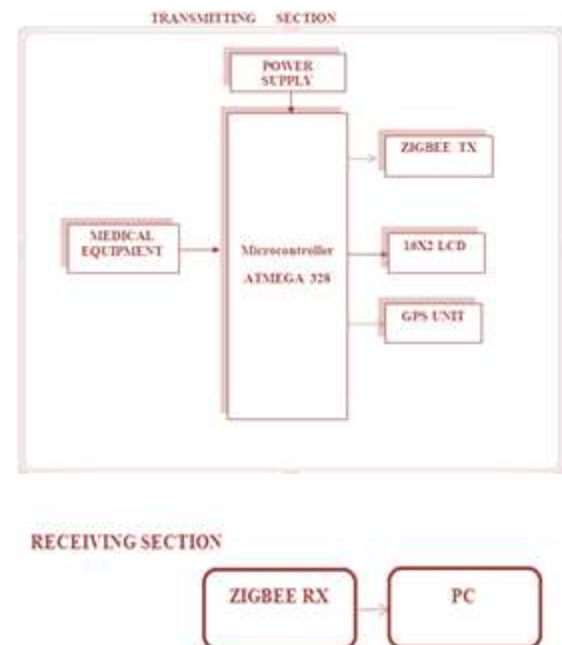


Fig.2 Block diagram of functional unit

### B. ZIGBEE

ZigBee® is a specification for a suite of high level communication protocols using small, low-power digital radios based on the IEEE 802.15.4-2003 standard for Low-Rate Wireless Personal Area Networks (LR-WPANs), such as wireless light switches with lamps, electrical meters with in-home-displays, consumer electronics equipment via short-range radio. The technology defined by the ZigBee® specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. ZigBee® is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking.

### C. GPS module

The GPS module used in this prototype is a generic GPS board that uses the u-blox6 GPS module and interfaces with the microcontroller through serial interface at 9600 bits/second [14]. Its horizontal position accuracy is within 2.5 m and outputs its data with NMEA GPRMC statements, which includes geographic location and UTC time.

**Features:** Embedded patch antenna: 15.0 x 15.0 x 4.0mm Extremely compact size: 16.0 x 16.0 x 6.45mm Automatic antenna switching function Support short circuit protection and antenna detection Built-in LNA for better sensitivity Ultra low power consumption in tracking mode, 20mA Always Locate™, an intelligent controller of periodic mode Support DGPS, SBAS(WAAS/EGNOS/MSAS/GAGAN) Anti-Jamming, Multi-tone Active Interference Canceller

#### General Specifications:

L1 Band Receiver (1575.42MHz):  
Channel : 22 (Tracking) / 66 (Acquisition) C/A code SBAS : WAAS, EGNOS MSAS, GAGAN  
Horizontal Position Accuracy :  
Autonomous: <2.5 m CEP  
Acceleration Accuracy :  
Without aid : 0.1 m/s<sup>2</sup>  
Timing Accuracy :  
1PPS out : 10ns  
Reacquisition Time : <1s  
Sensitivity :  
Acquisition : -148dBm Tracking : -165dBm  
Reacquisition : -160dBm

### III. RESULTS AND DISCUSSIONS

This system would comprise of two parts: multiple transmitting devices located in patients' homes and connected to patients' DME, called User Nodes, for gathering relevant live data to be transferred to the hospital and one central receiving device located in a local hospital, called the Base Station, for collecting the patient and DME information sent by the User Nodes.



Fig.3 Durable medical equipment

When a break of AC powersupply is detected at a certain location, the user node would send information towards the Base Station in the hospital. The information includes patient information (i.e., name, age, disease, type and brand of DME being used, etc.), GPS location of the patient and DME, and the power outage status (i.e. how long the DME has been running using battery power and how much battery life is remaining).

### IV. CONCLUSION

Given testing data, it was found that the prototype design of the DME tracking system was feasible to implement and would meet the requirement for securely transmitting patient data, location information, and the status of DME to a nearby hospital during power outages. Although the maximum radio range for the current pilot prototype was found to be 90 m, the advantage of modular design allows this proof-of-concept system to be easily scalable by simply employing more powerful radio modules or having specially placed forwarding nodes to facilitate the forwarding of information from more distant homes.

### REFERENCES

- [1] Durable medical equipment. [http://en.wikipedia.org/wiki/Durable\\_medical\\_equipment](http://en.wikipedia.org/wiki/Durable_medical_equipment)
- [2] National Coverage Determination (NCD) for Durable Medical Equipment Reference List (280.1). <http://www.cms.gov/medicare-coverage-database/details/ncddetails.aspx?NCDId=190&ncdver=2&NCAId=27&NcaName=Electrostimulation+for+Wounds&IsPopup=y&bc=AAAAA%3D%3D>
- [3] Baseline country survey on medical devices, 2013 update: Medical Equipment–Total density per million population computed tomography. [http://gamapserver.who.int/gho/interactive\\_charts/health\\_technologies/medical\\_equipment/atlas.html](http://gamapserver.who.int/gho/interactive_charts/health_technologies/medical_equipment/atlas.html)
- [4] B. Norman. What Will You Do if the Power Goes Out? <http://alsn.mda.org/article/what-will-you-do-if-power-goes-out>

[5] HHS Press Office. HHS selects winners in idea challenge for emergency response. <http://www.hhs.gov/news/press/2014pres/02/20140220a.html>

[6] GPS Trackers for Today's World. <http://www.pocketfinder.com/> [7] Zoombak Personal GPS Locators. The next generation Zoombak is eZoom. <http://www.securusgps.com/zoombak.aspx>

[8] SparkFunXbee shield. <https://www.sparkfun.com/products/12847>

[9] Teensy USB Development Board. <https://www.pjrc.com/teensy/>

[10] ZigBee® Alliance. <http://www.zigbee.org/54>.